To study the anatomical variations of the posterior interosseous artery and its clinical applications

Dissertation submitted to

THE TAMILNADU Dr. M. G. R. MEDICAL UNIVERSITY

In partial fulfillment of the
regulations for the award of the degree of

MCh (PLASTIC SURGERY)
BRANCH III

MADRAS MEDICAL COLLEGE & GOVERNMENT GENERAL HOSPITAL

THE TAMIL NADU DR. MGR. MEDICAL UNIVERSITY
CHENNAI, INDIA

August 2008

DECLARATION

I solemnly declare that this dissertation ***"To study the anatomical variations of the posterior interosseous artery and its clinical applications"*** was prepared by me in the Department of Plastic, Reconstructive and Maxillofacial Surgery, Madras Medical College and Government General Hospital, Chennai under the guidance and supervision of Professor & HOD Department of Plastic, Reconstructive and Maxillofacial Surgery, Madras Medical College and Government General Hospital, Chennai between 2005 and 2008**.**

This dissertation is submitted to the TamilNadu Dr. MGR Medical University, Chennai in partial fulfillment of the University requirements for the award of degree of MCh Plastic Surgery.

Place: Chennai

Date :

CERTIFICATE

This is to certify that this dissertation entitled "**To study the anatomical variations of the posterior interosseous artery and its clinical applications"** is a bonafide record of the research work done by Dr Rohini for the award of MCh Plastic Surgery, under the supervision of, Professor & HOD, Plastic Surgery Madras Medical College and Government General Hospital, Chennai between 2005 and 2008.

I also certify that this dissertation is the result of the independent work done by candidate.

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INSTITUTIONAL ETHICAL COMMITTEE

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Lr.Dis.No.3798/P&D3/Ethics/Dean/GGH/08 **Dated:15/2/2008**

Title of the work : Anatomical variations of the posterior Interosseous Artery and its clinical applications.

Principal investigator : Dr. Rohini

Department : Plastic Surgery. MMC, ch.3.

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 15/2/2008 at the Conference Hall of the Dean, Tower Block I, Government General Hospital, Chennai.3.

The members of the Committee, the Secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The principal investigator and their team are directed to adhere the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.
3. You should inform the IEC in case of any change of study procedure, site and investigation or guide.
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INTRODUCTION

INTRODUCTION

Management of soft tissue defects of the hand is one of the most challenging issues in hand surgery. Defects may be sequelae of trauma, burns, congenital anamolies , tumour resection or infection. Their treatment may require not only surgical techniques such as simple skin grafting or local transposition flaps but also microsurgical procedures.

The armamentarium for the treating hand surgeon consists of local techniques at the hand and forearm and free microsurgical techniques or distant flaps from other regions of the body[1]. In the past few years, new flaps have been explored with a more careful evaluation of donor sites; also, newly developed techniques such as the perforator flap and the propeller flap have come into the focus of interest. New flap techniques have to

prove their advantages over established techniques with their well-known possibilities and risks before becoming routine procedures. The advantages and disadvantages of each technique regarding difficulty of harvest, reliability of anatomy, donor-site defect and other issues have to be carefully weighed one against the other when choosing the best technique suitable for each patient.

Over the past 20 years the retrograde radial forearm fasciocutaneous flap has gained widespread acceptance in reconstruction of these defects. Appreciation of the inherent limitations of this workhorse flap and increased understanding of the blood supply of the upper extremity have prompted the development of several alternative pedicled forearm flaps. Aspects of surgical technique, specific limitations, and indications for the radial forearm fascial flap, the posterior interosseous artery flap, the retrograde radial

artery perforator flap, and the dorsal ulnar artery flap need to be known[1]. Other techniques are skin grafting, abdominal flap, groin flap, chest flap, supraclavicular flap and microvascular free tissue transfer.

The Posterior Interosseous Artery flap has emerged as a versatile alternative amongst the armamentarium of reconstructive techniques for the hand. Large fasciocutaneous island flaps can be harvested, even when the radial or ulnar pedicles are damaged, sacrificing only vessels of secondary importance to the perfusion of the hand, sparing the axial vessels of the hand[3]. Compound flaps can be dissected based on muscular, musculoperiosteal and fascioperiosteal branches. The primary indications for using this flap are dorsal hand defects up to the metacarpal joints, reconstruction of the first web space up to the interphalangeal joint of the thumb and

extensive lesions on the ulnar border of the hand[1,3].

The posterior interosseous vessels give a significant contribution to the fascial plexus which supplies the skin of dorsum of the forearm. This vascular arrangement forms the basis for an island fasciocutaneous flap which can be based either proximally or distally.

This cadaveric and clinical study is aimed to establish the reliability and versatility of this flap.

AIMS AND OBJECTIVES

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1. To study the anatomical variations of the posterior interosseous artery and its clinical applications and to examine the posterior interosseous artery in the light of the **ANGIOSOME** concept while defining the cutaneous territory of this artery, muscle and bone blood supply.

2. To define the technical aspects of safe raising of the Posterior Interosseous Artery Flap and to define the safe technique of recruitment of larger tissue in the flap.

3. To obviate the necessity of test dissection prior to raising the flap.

4. To define the necessity and modified technique of **Buchler and Frey** procedure.

MATERIALS AND METHODS

MATERIALS AND METHODS

AIM OF THE STUDY:

To study the Anatomical variations in the Posterior Interosseous Artery and its Clinical applications, to define technique of safe raising of flap, technique of recruitment of larger tissue, and to define the Buechler and Frey phenomenon.

DURATION OF STUDY:

September 2005 to April 2008

VENUE OF STUDY:

Department of Plastic, Reconstructive, Maxillofacial Surgery, Madras Medical College,

Government General Hospital and Department of Anatomy, Madras Medical College.

PATIENT SELECTION CRITERIA:

1. 20 in number

2. Patients with defects of dorsum of hand, forearm, volar aspect of forearm and dorsum of proximal phalanges and first web space.

3. No exclusion criteria.

4. All these patients were primarily planned for a Posterior Interosseous Artery flap if Doppler examination confirmed the presence of perforators.

5. The pre-operative Doppler was done by 8MHz hand held Doppler.

NUMBER OF CADAVERIC DISSECTIONS:

10 in number of which 2 dissections were done in freshly amputated limbs.

METHOD OF STUDY:

The study was conducted by performing dissection on dorsum of forearm and noting the course of Posterior Interosseous Artery, its perforators and the distal anastomosis. The same was done while raising the flap in the clinical cases.

In all the dissections the flap was raised proximo-distally, based on the distal communication between posterior and anterior interosseous artery.

Observations:

- Clinical observations such as location of the artery, Posterior interosseous nerve, perforators etc were noted.

METHODS:

Proximal third of forearm

Entry of PIA in the posterior compartment:
Site of origin of Interosseous recurrent artery: (oblique cord/ interosseous membrane):
Course of IRA (Deep to Anconeus/ Anconeus & Supinator)
No. of perforators from IRA:
Size of PIA in the post comptt:
Relation of PIN and PIA (Buechler and Frey phenomenon):

Middle third of forearm

Course of PIA:
Location of septo-cutaneous perforators (EDC-EDM/EDM-ECU)
No. of perforators:
Size of perf at origin:

Distal third of forearm

Course of vessel (no. of cm from ulna)
Site of anastomosis between AIA and PIA

- Measurements were made on a linear scale and calipers
- Digital photographs were recorded.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soft-tissue defects of the hand and wrist commonly occur in the context of high-energy trauma. Less commonly they may be an end point of extirpation of infected or neoplastic tissue, or burn injuries. Borderline vascularity of the adjacent tissues, contamination or frank infection, and associated defects in the underlying bones, tendons, or neurovascular structures may complicate reconstructive efforts[2]. A clean noninfected wound, a viable extremity, skeletal stability, an adequately resuscitated patient, and suitable expertise and equipment all are prerequisites for successful soft-tissue reconstruction in these cases.

Standard reconstructive paradigms serve as a broad guide to planning that can be tailored to the demands of the situation. Simpler reconstructive options such as secondary intention healing,

delayed primary closure or skin grafting have a role in smaller defects or where tissue loss has not left important or relatively poorly vascularized tissues exposed. Topical negative pressure dressings (VAC, Kinetic Concepts Inc., San Antonio, TX) have extended the situations in which these simpler reconstructive procedures can be applied. Frequently, however, a more durable and expedient soft-tissue coverage is required. Local flaps have limited application because there is a paucity of expendable donor tissue in the hand, flap mobility is restricted, and sublethal injury to adjacent tissues in the case of trauma may impair their viability for transfer[1]. Distant pedicled flaps from the groin, trunk, or contralateral arm were traditionally the mainstay of reconstruction in these situations but they provide a bulky reconstruction that requires at least 2 stages with an intervening period of immobilization and dependency with significant time and tissue

wastage. The development of microvascular techniques for free tissue transfer in the 1970s addressed many of these shortcomings at the expense of increased procedural complexity, duration, and demand on resources.

RECONSTRUCTIVE TECHNIQUES FOR HAND AND DISTAL FOREARM

The radial forearm fasciocutaneous flap[1,3,4] was described initially as a free flap by Yang et al in 1981 and only later as a retrograde-flow pedicled flap for hand reconstruction by Lu et al in 1982. Recognition of the potential for retrograde flow in distally pedicled radial forearm flaps was a notable contribution to hand surgery because large areas of relatively thin skin and fascia with a robust blood supply now could be harvested from within the same surgical field and transferred without the need for microvascular technique in a

single-stage procedure that facilitated postoperative elevation and early mobilization.

Several drawbacks to the radial forearm flap have become apparent with collective experience. Sacrifice of the radial artery is rarely of consequence in the appropriately selected patient but on occasion may require vein graft reconstruction. More importantly this precludes its use in patients with clinically absent/questionable distal ulnar–radial vascular communications. The abundant skin and fascia that can be transferred in the flap is durable and pliable but often a poor match in terms of bulk and color for tissue replacement in the hand. Additional shortcomings relate to the conspicuous donor site; which can be subject to poor skin graft take and delayed healing, particularly in the distal third of the forearm . These limitations together with advances in knowledge of the blood supply of the forearm

have driven the development of alternative distally based pedicled forearm flaps.

Radial Forearm Fascial Flap

In 1985 Jin et al[1] described their experience with harvesting large areas of the volar forearm fascia pedicled distally on the radial artery and its venae comitantes to reconstruct hand defects. Up to two thirds of the volar, lateral, and dorsal circumference of the forearm fascia (10–12 cm width × 20–30 cm length) can be elevated through a curvilinear forearm incision and transferred to cover the entire dorsal or palmar surface of the hand, extending distally to the level of the midproximal phalanx. A split-thickness skin graft is required to cover the flap after inset, but the technique allows for primary closure of the forearm donor site in most instances.

Improved donor site aesthetics is the main benefit of this flap over the more conventional retrograde radial forearm fasciocutaneous flap. Donor site healing usually is not problematic and leaves a more acceptable curvilinear scar. Large areas can be covered with thin vascular tissue, which in comparison contour particularly well to the dorsum of the hand. The distal reach of this fascial flap is similar to the retrograde radial forearm fasciocutaneous variant and generally is superior to the alternative pedicled forearm flaps that are discussed later.

Because of its thinness a split-skin grafted fascial flap, however, may provide a less favorable environment for secondary procedures such as staged tendon grafting. Furthermore the retrograde radial forearm fascial flap does not contain the cutaneous sensory end organs required for potential neurotization via the lateral antebrachial

cutaneous nerve. When these additional procedures are planned consideration should be given to a fasciocutaneous flap.

Retrograde Posterior Interosseous Artery Flap

Since Zancolli and Angrigiani[5,6] first described this flap in 1985 for proximal elbow defects, widespread experience has shown its reliability and versatility. Fascia and skin up to 12 to 15 cm in length and 8 to 10 cm in width can be based proximally or distally on the posterior interosseous artery (PIA) as it courses between the extensor digiti minimi and the extensor carpi ulnaris[6]. Distally pedicled flaps will reach to the dorsum of the metacarpophalangeal joints, the first web space, and the proximal and ulnar part of the palm. Retrograde perfusion is dependent on an intact distal communicating artery between the anterior and posterior interosseous arteries just proximal to the distal radioulnar joint. In

approximately 5% of forearms this distal communication is absent[6,7]; therefore when preoperative radiologic confirmation of its presence is not available it is necessary to explore the pedicle before flap elevation.

The main advantage of this flap over the previously described retrograde radial artery flaps is that it does not require the sacrifice of a major limb vessel. The rare complications of acute or chronic arterial insufficiency after radial artery harvest are therefore avoided, the requirement for intact distal ulnar–radial arterial communication to raise a distally based radial forearm flap no longer applies[8].

Skin color and contour from the dorsal forearm are a closer match for the dorsal hand than volar forearm flaps and the flap can be neurotized by including a proximal length of posterior antebrachial cutaneous nerve for

microneurorrhaphy to a suitable donor nerve[5]. Smaller fasciocutaneous flap donor sites up to 3 to 4 cm in width can be closed primarily but larger defects will require skin grafting. The flap can be raised as an osteo-cutaneous, free flap, and as a propeller flap. Although skin graft healing is rarely problematic on the well-vascularized muscle bed at the donor site, one of the main disadvantages of this flap is that the resultant scar is particularly conspicuous if a skin graft is required for closure.

Additional criticism of the PIA flap has centered on the anatomic variation and size of the pedicle vessels. Familiarity with these variations, a meticulous dissection technique, and a viable contingency plan is required to elevate this flap safely.

Retrograde Radial Artery Perforator Flap

In a further effort to preserve radial arterial flow to the hand Chang et al in 1988 described the first clinical series using a retrograde radial forearm flap with an arterial inflow based only on the septocutaneous perforators arising from the distal radial artery. Subsequent anatomic studies and limited published clinical experience have shown the reliability of retrograde flow to and from perforating vessels arising from 1 to 3 cm proximal to the radial styloid along a longitudinally oriented adipofascial plexus in the distal forearm adipofascial layer that forms the vascular pedicle for these flaps[4,7]. Because retrograde flow is dependent on a plexus rather than a major vascular axis, the maximum dimensions of the flap that can be transferred reliably (8–12 cm width × 15–20 cm length) are smaller and the maximum reach more proximal than for the true axial flaps

previously described. Both islanded fasciocutaneous and turnover adipofascial flap variants of this flap have been described.

Similar to the posterior interosseous flap, elevating this flap does not sacrifice a major limb vessel and is not dependent on intact distal ulnar–radial arterial communication. Provided there is an intact radial artery and venae comitantes to the wrist the distally based perforator flap can be used to cover moderate-sized defects of the dorsum or palm of the hand as far as the base of the proximal digital phalanges.

Donor site healing usually is not problematic in the proximal forearm, although a skin graft will be required for donor site defects larger than 3 or 4 cm in width. With the wide adipofascial pedicle that must be raised with this flap along with the lower arterial perfusion pressures it generally is safer to incise the skin between the pivot point and

the recipient site and skin graft the bulky pedicle rather than attempting to tunnel it beneath an intact skin bridge.

The vascularity of this flap is not as good as the aforementioned radial artery flap and the defect size and distal extent will preclude its use in some clinical scenarios. Alternative flaps probably should be considered in patients at risk for microvascular arterial disease, such as smokers or diabetics, or in those with a history of venous insufficiency or thrombosis in the affected limb.

Dorsal Ulnar Artery Flap

Becker and Gilbert[1] described a fasciocutaneous flap in 1988 based on this branch of the ulnar artery arising 2 to 4 cm proximal to the pisiform bone. The 1- to 2-mm dorsal ulnar artery (DUA) and accompanying venae comitantes pass deep to the musculotendinous junction of the flexor carpi

ulnaris muscle with the dorsal branch of the ulnar nerve. After giving off branches to the pisiform and flexor carpi ulnaris muscle the artery divides into ascending and descending branches that supply the ulnar border of the forearm, wrist, and hand. The ascending branch forms the vascular basis for a distally pedicled island or peninsula flap up to 5 to 9 cm in width and 10 to 20 cm in length with potential to reach to the defects over the dorsum of the hand, the ulnar half of the palm, and the dorsal and volar wrist.

This flap shares the advantages of the distal radial artery perforator flap and the posterior interosseous flap in terms of providing thin, pliable, and potentially sensate soft-tissue coverage to the hand without sacrificing a major vascular axis or dependency on intact distal ulnar–radial arterial communication. In general the donor site scar on the ulnar border of the forearm

is less conspicuous than radial or posterior forearm flap donor sites.

More recently several investigators have presented limited series describing further variations in dorsal ulnar artery flap design: proximally based flaps based on the descending branch of the DUA, more distally based flaps perfused by communications between the DUA and the fourth intermetacarpal artery, and composite flaps that include a segment of ulna. The flap potentially can be neurotized by elevating a proximal length of the medial antebrachial cutaneous nerve with the flap for microneurorrhaphy to a suitable donor nerve in the hand.

The main disadvantage of the flap is related to its shorter pedicle length in comparison with the aforementioned flaps. The DUA flap as it is described conventionally will not reach to cover defects on the radial border of the hand.

Peninsula-design DUA flaps have a further restricted arc of rotation and may require delayed secondary excision of an unsightly standing cone of skin at the base of the pedicle.

Distant Flaps

Groin Flap : First described by Taylor and Mc Gregor[4] it was considered the workhorse flap for reconstruction of hand. The vascular basis is the Superficial Circumflex iliac artery. The main advantages are the ease of flap raising, minimal donor site morbidity and reliability of the flap. The main disadvantages are immobilization and dependant position of the hand and staged procedure. The flap is bulky with poor colour match esp for the palmar defects.

Abdominal Flap: It is a random pattern flap technically easy to raise and large flaps can be raised to cover hand and forearm defects. The

disadvantages include immobilization and dependant position of hand . The donor site needs to be skin grafted.

Microvascular Free tissue transfer: The free tissue transfer has broken all limitations of size , quality and availability of donor tissue. It is a single staged procedure. The limitations are technical training required for microvascular surgery, long duration of procedure, and the costs involved.

Extensive palmar defects in particular are likely to require distant pedicled or free tissue transfer because distal communications between radial and ulnar arteries are likely to be compromised and flaps based on these major vessels will be unavailable for regional reconstruction. Moderate-sized palmar defects still may be reconstructed with alternative regional flaps that are not dependent on an intact distal vascular arcade:

radial palmar defects can be covered with the retrograde radial perforator flap and ulnar palmar or proximal palmar defects with the posterior interosseous or dorsal ulnar artery flaps. Surgeons generally prefer thin fasciocutaneous flaps to adipofascial flaps with skin grafts on the palm because they are more durable, more amenable to procedures involved in secondary tendon reconstruction, and offer the option of neurotization of the flap.

Extensive dorsal defects also may require distant pedicled or free tissue transfer should doubt exist regarding the patency of distal ulnar–radial communications. When this is not the case the retrograde radial forearm fascial or fasciocutaneous flap frequently will best meet the dimensions of an extensive dorsal defect. Provided that secondary tendon surgery is not anticipated, a fascial flap covered with a thick unmeshed split-

skin graft usually is preferable to a fasciocutaneous flap in these instances because of its superior donor site aesthetics. For intermediate-sized dorsal defects the posterior interosseous artery flap will provide thin pliable skin and fascial coverage and is our flap of choice. The dorsal ulnar flap and the distal radial artery perforator flap are useful flaps for smaller predominantly ulnar or radial defects, respectively, with aesthetically superior donor site scars. Either the PIA flap or the distal radial artery perforator flap will provide suitable reconstruction for the first web space.

THE POSTERIOR INTEROSSEOUS ARTERY FLAP

The skin of the dorsal aspect of the forearm is supplied by several cutaneous branches of the posterior interosseous artery[6]. This vascular anatomy permits the surgeon to obtain an island flap of the dorsal forearm based on the distal anastomosis between the two interosseous arteries at the distal part of the interosseous space. The posterior interosseous vessels give a significant contribution to the fascial plexus which supplies the skin of the forearm[6]. This vascular arrangement forms the basis for an island fasciocutaneous flap which can be based either proximally or distally This flap can reliably be transferred to different skin defects of the hand such as those created by correction of an adduction contracture of the first web space, or on the back or front of the wrist level. Its principal

advantages are that it is a thin flap with excellent circulation and that it is possible to close the donor area primarily provided the island flap is not wider than 3 to 4 cm. Large fasciocutaneous island flaps can be harvested, even when the radial or ulnar pedicles are damaged. One real advantage is that the posterior interosseous artery is a vessel of secondary importance for hand vascularisation[8,9]. Fasciocutaneous and osteofasciocutaneous island distally based flaps can be tailored. The major indications are reconstruction of the first web space up to the interphalangeal joint of the thumb, dorsal hand defects up to the metacarpal joints and large defects on the palm-ulnar border of the hand. It is, therefore, a primary weapon amongst hand reconstruction techniques.

The Posterior Interosseous Artery flap is a fasciocutaneous flap which can be proximally or distally based as an island flap. It is generally raised as a distally based pedicle flap with reversed

blood flow to cover small to medium sized defects on the dorsum of hand, distal forearm and palm of the hand[10]. It was described by Zancolli, Angrigiani in 1985, and its anatomical basis was described by Penteado and Masquelet[11] in the same year. Further variations and wider spectrum of applications including the osteo-fasciocutaneous flap was described by Costa [10]et al in 1988. Bayon[5] and Buechler[13] have described a sensate flap based on the antebrachial nerve in 1991. Others who have studied the vascular basis of the flap are Bayon and Pho[5], and Ding[14] et al.

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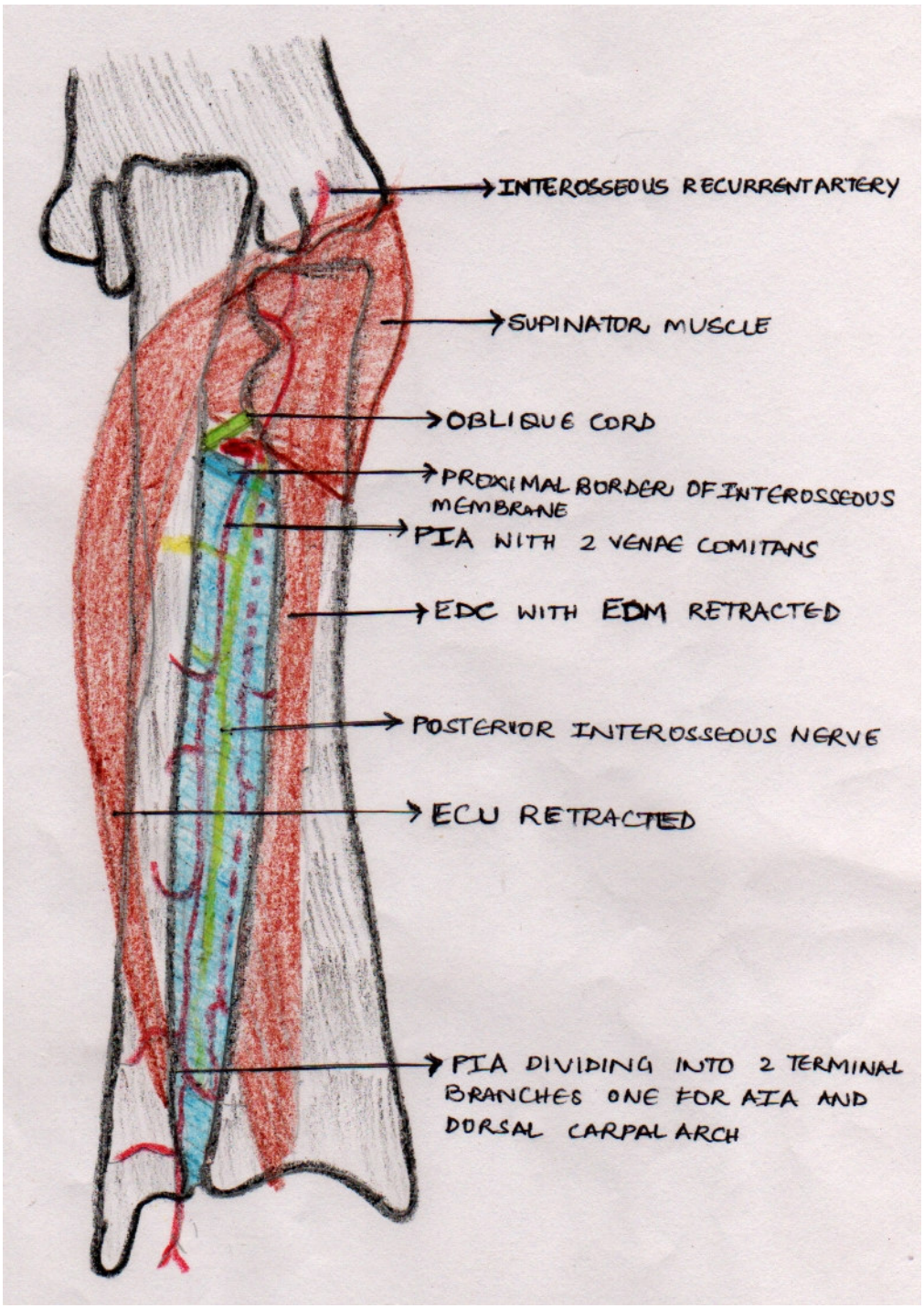
VASCULAR ANATOMY OF THE DISTALLY BASED POSTERIOR INTEROSSEOUS FLAP

The PIA flap is a fasciocutaneous flap based on the posterior interosseous artery which lies invested by the fascial septum between the Extensor Carpi Ulnaris and Extensor Digiti Minimi usually. The artery gives off septocutaneous branches that spread out on the deep fascia to form longitudinal fascial arcades, as well as further branches that pass through the deep fascia to supply the underlying deep extensor muscles. It also gives a nutrient artery to the ulna around 12-15 cm from the ulnar styloid process[12]. In the lower third of the posterior forearm, direct septo-periosteal branches to the ulna are present.



VASCULAR ANATOMY OF THE POSTERIOR INTEROSSEOUS ARTERY FLAP

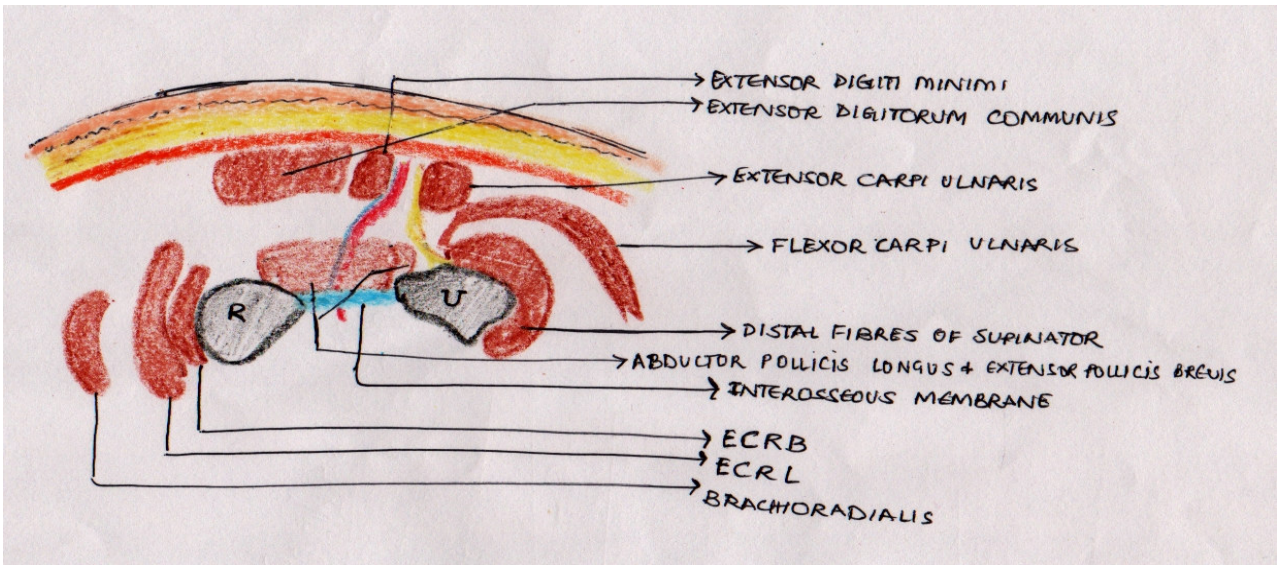
COURSE OF THE POSTERIOR INTEROSSEOUS ARTERY

It originates from the Common Interosseous Artery or the Ulnar Artery and passes between the oblique cord and interosseous membrane and emerges in the deep extensor compartment of the forearm underneath the supinator at a distance of 13-17 cm from the ulnar styloid. At this point the interossoeous recurrent artery emerges and runs proximally deep to the Anconeous giving off fasciocutaneous and Musculocutaneous perforators. At its emergence in the deep posterior forearm its external diameter ranges from 1.5-2.5 mm accompanied by at least two venae comitans- running in the septum between Extensor Carpi Ulnaris and Extensor Digiti Minimi giving off fasciocutaneous perforators throughout its length. Here it gives muscular branches to Abductor

Pollicis Longus, Extensor Pollicis Longus, Extensor Indicis and periosteal branches to the ulna.

The Posterior Interosseous Nerve arises from the radial nerve in front of the lateral epicondyle of the humerus in the cubital fossa. It pierces the supinator, winds around the lateral aspect of the neck of radius in the substance of the muscle, to reach the posterior compartment of the forearm. After emerging from the supinator the nerve gives three short branches to the extensor digitorum, extensor digiti minimi and extensor carpi ulnaris; two long branches—the medial branch supplying the extensor pollicis longus, the extensor indicis, and the lateral branch supplies the abductor pollicis longus and extensor pollicis brevis[15]. The nerve lies at first between the superficial and deep muscles of the back of the forearm along the posterior interosseous artery. The branch for the Extensor Carpi Ulnaris passes through the index septum proximal or distal to the most proximal

perforator from the PIA. This relation to the important cutaneous perforator and the PIA itself is important in the dissection of the flap to avoid denervation of the extensor muscles and to preserve flap viability[13] (Buchler and Frey Phenomena).



CUT SECTION OF THE DORSUM OF PROXIMAL THIRD OF FOREARM

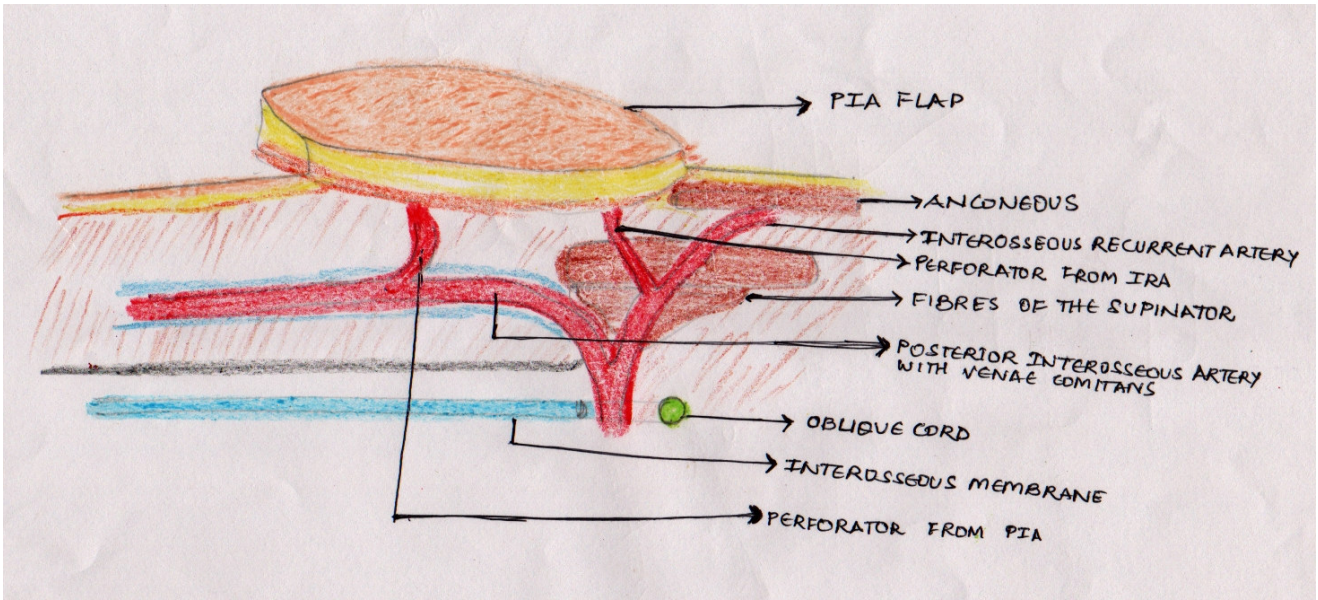


DIAGRAM SHOWING ORIGIN OF PIA AND IRA AND THE Y-V PRINCIPLE OF BAUDET

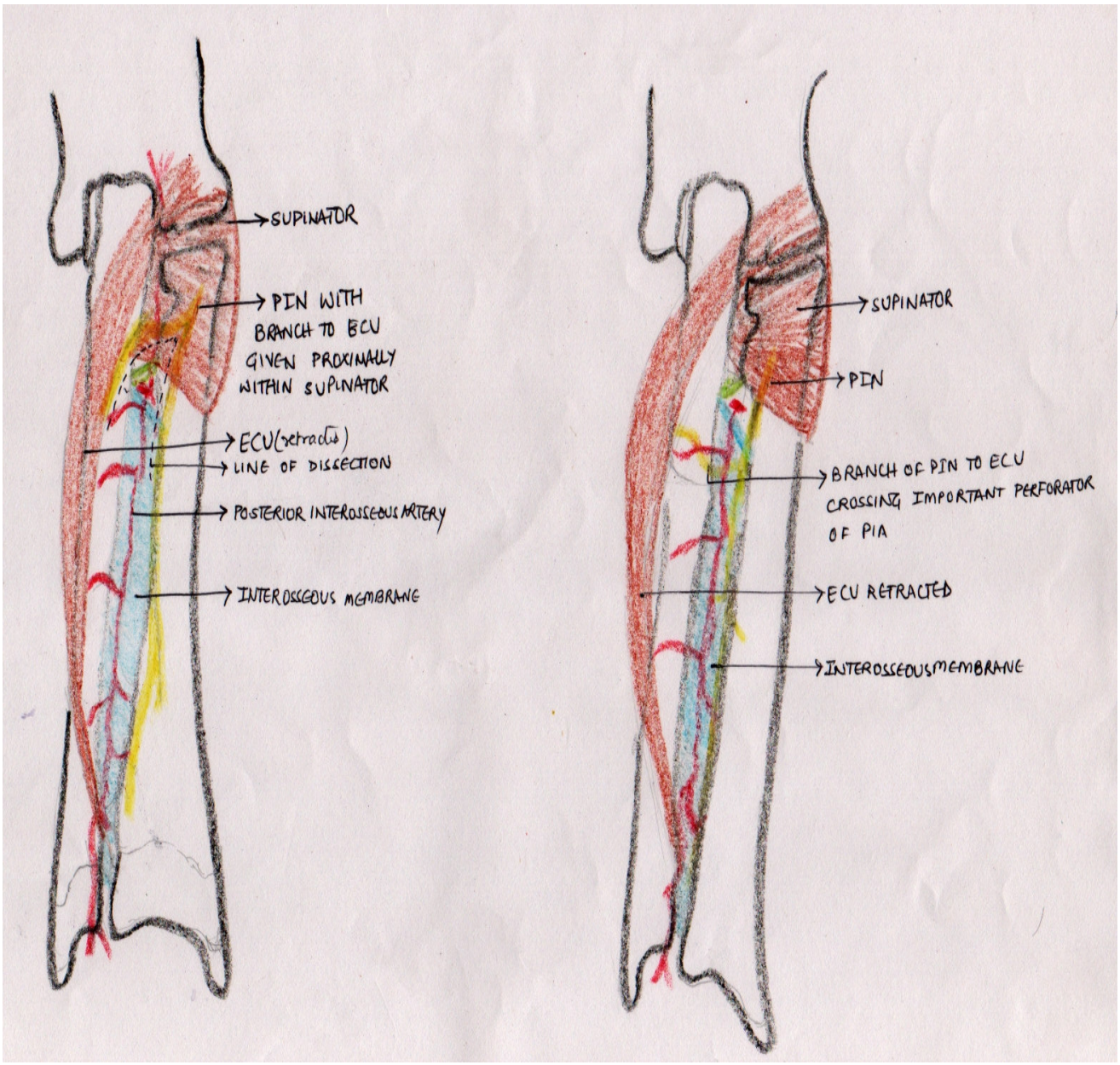
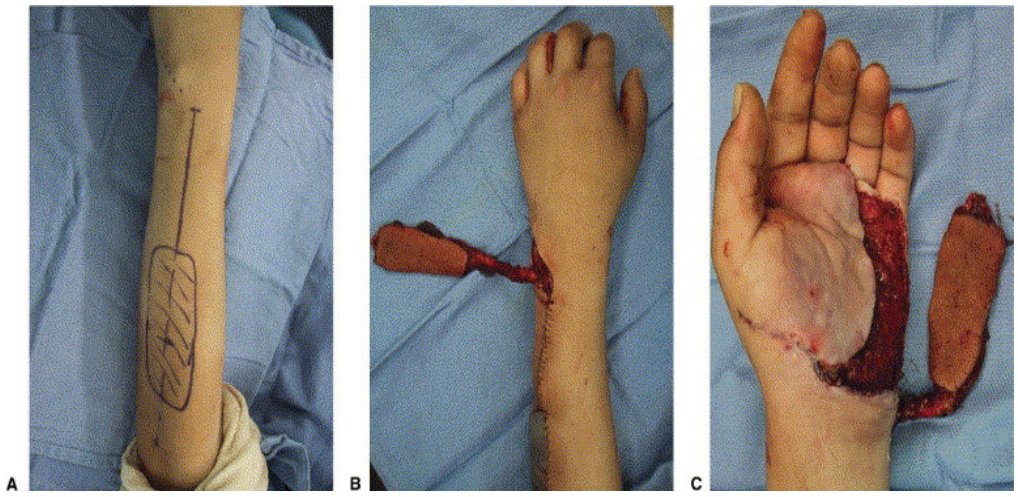


DIAGRAM ILLUSTRATING THE BUECHLER AND FREY PHENOMENON

TECHNIQUE OF FLAP RAISING (CONVENTIONAL)

The required flap dimensions are determined using a cut-to-fit template of the defect and the required pedicle length is measured from the pivot point 2 cm proximal to the distal radioulnar joint with due consideration to avoid kinking or tension in the pedicle after rotation. In the original technique described by Zancolli[6] the dissection begins by making an incision along the line proximal to the pivot point to ascertain the distal PIA communication with the AIA and if the vessel was not found satisfactory the surgery is abandoned (TEST DISSECTION). The axis of the flap is planned along a line joining the lateral epicondyle and the distal radioulnar joint . At approximately the midpoint of this axis is the middle (median) perforator of the PIA, which should be included in the flap design; its location can be confirmed by

intraoperative Doppler sonography. The reliable proximal limit of the flap is 6 cm distal to the lateral epicondyle based on this vessel[16, 17, 18]. A more proximal perforator is present consistently but this vessel variably (30%) may originate from the recurrent interosseous branch of the PIA and has a variable relationship to the main motor branch to the extensor carpi ulnaris that necessitates division and subsequent repair of the nerve if the vessel is included with the flap. According to the experience of Zancolli and Angrigiani[19] it seems to add little to the viable length of flap that can be raised. An adipofascial pedicle is raised with the artery till it gives its anastomotic branch to the anterior interosseous artery. The flap is inset into the defect by tunneling or opening the intervening segment of skin. Donor area is closed primarily or skin grafted.



A: Axis and marking of flap dimensions

B: Flap raised as an island with an adipofascial pedicle

C: Flap inset to be given in the defect by exteriorizing the pedicle

VARIATIONS IN THE COURSE OF POSTERIOR INTEROSSEOUS ARTERY (*as described in literature so far)*

The Posterior Interosseous Artery originates from the Common Interosseous Artery (85% of cases) or the Ulnar Artery (15% of cases) at 14to 17cm from the ulnar styloid process in the posterior compartment of the forearm[13]. The Interosseous recurrent artery emerges either at the level of the oblique cord or the Interosseous membrane and it courses in the extensor compartment either deep to the Anconeus or deep to both Anconeus and the Supinator muscle. The Interosseous Recurrent Artery gives off one or two cutaneous perforators which supply the proximal third of the dorsum of forearm if raised with the flap helps to recruite more tissue[14,16]. There may be absence of Interosseous Recurrent Artery or hypoplasia or there may be no cutaneous perforators arising

from it. The diameter of the Posterior Interosseous artery at its origin varies from 1.5 to 2.5mm but there are reports of hypoplastic PIA just distal to origin or in the middle third. The site of the intermuscular septum where most of the septo-cutaneous perforators supplying the dorsum of the forearm are found may lie between the Extensor digiti minimi and the Extensor Carpi Ulnaris or the Extensor Digiti Minimi and the Extensor Digitorum Communis. There are reports of poorly developed or hypoplastic septum and the PIA giving off only musculocutaneous perforators and no septocutaneous perforators[18]. The pattern of distribution of the septocutaneous perforators and their number in the proximal middle and distal thirds of the artery varies. Similarly the number and distribution of the musculocutaneous perforators and periosteal branches also varies. The relation of the branch of the Posterior Interosseous Nerve[11,19] to the Extensor Carpi

Ulnaris to the most proximal and clinically most important perforator of the Posterior Interosseous Artery is variable and this is important for reliability of the flap as well as to avoid extensor paresis in the post-operative period. Many authors have reported anatomical variations in the distal anastomosis between the Anterior and Posterior Interosseous Artery. Some of them are:-) failure of the middle third of the PIA(Penteado et al[11]), absence of choke anastomoses between the recurrent dorsal branch of the AIA and PIA at the level of middle third of forearm(Angrigiani et al[19]), hypoplastic PIA in the middle third (Giunta and Lukas[20]), narrowing of the PIA to a small caliber in the middle third of the forearm (Angrigiani[11]) and termination of the PIA in the middle third of the forearm.

BASIS OF OUR ANATOMICAL CLINICAL AND STUDY

To analyze the Posterior Interosseous flap on the following points:

1. Requirement of test dissection
2. Flap design and Size of flap
3. Method of dissection- Technically demanding
4. How to increase reliability of flap
5. How to improve reach of the flap

1. **Requirement of test dissection**

In the conventional flap reported by Zancolli[5] et al., blood perfusion is maintained by anastomosis between the anterior and posterior interosseous artery at the level of the wrist. However, a disadvantage of the conventional flap is that partial or even complete necrosis takes place if anatomical variations of the blood supply such as

hypoplasia and contusion of the posterior interosseous artery or tissue damage including blood vessels are encountered. Other rare anatomical variations include

1) failure of the middle third of the PIA(Penteado et al)[11]

2) absence of choke anastomoses between the recurrent dorsal branch of the AIA and PIA at the level of middle third of forearm(Angrigiani et al)[19]

3) Hypoplastic PIA in the middle third (Giunta and Lukas) [20]

4) Narrowing of the PIA to a small caliber in the middle third of the forearm (Angrigiani)[11]

5) Termination of the PIA in the middle third of the forearm

Earlier procedures for raising the PIA flap were preceded by a test dissection to confirm the presence of anastomosis between AIA and PIA and the flap was abandoned in case of absence of

anastomosis or proximal termination of the PIA. Recent studies elucidate the use of hand held Doppler[24] to confirm the anastomosis and the reverse flow phenomenon. However, the controversy regarding the necessity of test dissection still continues.

2. Flap design and Size of flap

In the conventional flap, the axis of the flap is planned along a line joining the lateral epicondyle and the distal radioulnar joint and this line is divided into thirds[5]. The safe limit of the flap was considered on the middle thirds with minimal proximal extent thus limiting the reach of the flap . Further the termination of the posterior interosseous artery in the wrist anastomosis was considered variable with respect to its existence and site. Studies by Costa et al[17,18] show nearly 95% of the times there is an anastomosis and it is

located around 3cm from the wrist joint. According to the experience of Zancolli and Angrigiani it seems that inclusion of the proximal perforator from the Interosseous Recurrent Artery seems to add little to the viable length of flap that can be raised. Subsequent studies including ours disclaim this and a deliberate attempt to include those perforators leads to recruitment of larger tissue and improves reach.

3. Method of Dissection

During raising of flap the dissection is carried out on the surface of Supinator after dividing and ligating the IRA proximally. Following the ***Y-V principle of Baudet*** we have ligated the stem of PIA close to the interosseous membrane. The dissection is continued from both radial and ulnar aspect distally where the AP dimensions of the septum are reduced and the vessels are

superficially running over the Extensor Indices Proprius. We proceed distally by carefully dissecting the sub-epimyseal plane of APL, EPL and EIP. There were multiple perforators to APL, one to EIP and two to EPL in all our dissections which were ligated during raising of the flap. Distally the PIA runs very close to the periosteum of ulna, radial to the ECU which is situated in the groove on the dorsal surface of ulnar styloid. From there on the ulnar directed smooth arch like bending of the artery runs beneath Extensor Digiti Minimi and Extensor Digiti Communis to make anastomosis with the Anterior Interosseous Artery.

After emerging between the superficial and deep fibres of the supinator the posterior interosseous nerve runs on the radial aspect of the posterior interosseous artery and its venae comitans. In relation to the proximal most perforator from the PIA we have observed in our studies, that the

branch to the Extensor Carpi Ulnaris is given off well proximally as it runs on the substance of the Supinator. In 35% of our cases as the branch to the ECU passes distal to the most proximal perforator of the PIA it is divided and subsequently anastomosed (***Modified Buchler and Frey phenomenon***) without any significant post-operative paresis.

4. To make it a more reliable flap

Three types of auxiliary procedures have been designed.

(1) The intermuscular septum and the deep fascia were included in the flap to augment circulation with the blood supply provided by septocutaneous perforators and suprafascial plexus.

(2) The skin over the pedicle and subcutaneous veins that anastomosed suprafascial plexus were

taken with the pedicle to avoid circulation impairment.

(3) Without passing the pedicle under a subcutaneous tunnel, a skin extension over the fasciovascular pedicle was used as a roof of the tunnel to prevent edema and congestion.

A series of Zancolli and Angrigiani in 1985 of 25 cases were reported with no complications at all. Masquelet and Penteado[11] reported only one case of partial necrosis in their series of 8 cases. Costa and Souttar in their series reported only 3 cases of venous congestion but no flap necrosis. Costa et al in 2001[10] reported their series of 78 cases with only one case of complete flap necrosis and 4 cases of partial flap necrosis. Brunelli[16] et al in 2001 reported an incidence of 13% in their study. They also reported extensor paralysis in 6 out of 113 cases. In most other series the venous congestion

of flap ranges from 5 to 22% whereas ischemic flap necrosis is between 3 to 10 %.

5. Maximization of the distal reach of the flap

1. Hyperextension of the wrist for a tension free pedicle in thumb reconstruction.
2. Exteriorizing the pedicle and keeping the wrist in extension (Brunelli et al)[16].
3. Distal dissection along the transverse anastomotic branch (Buechler et al)[13].
4. Tunneling the pedicle and flap through a hole in the interosseous membrane to cover a volar wrist defect (Gupta et al) [22].

Other rare anatomical variations include

1) Failure of the middle third of the PIA (Penteado et al) [11]

2) Absence of choke anastomoses between the recurrent dorsal branch of the AIA and PIA at the level of middle third of forearm(Angrigiani et al)[19]

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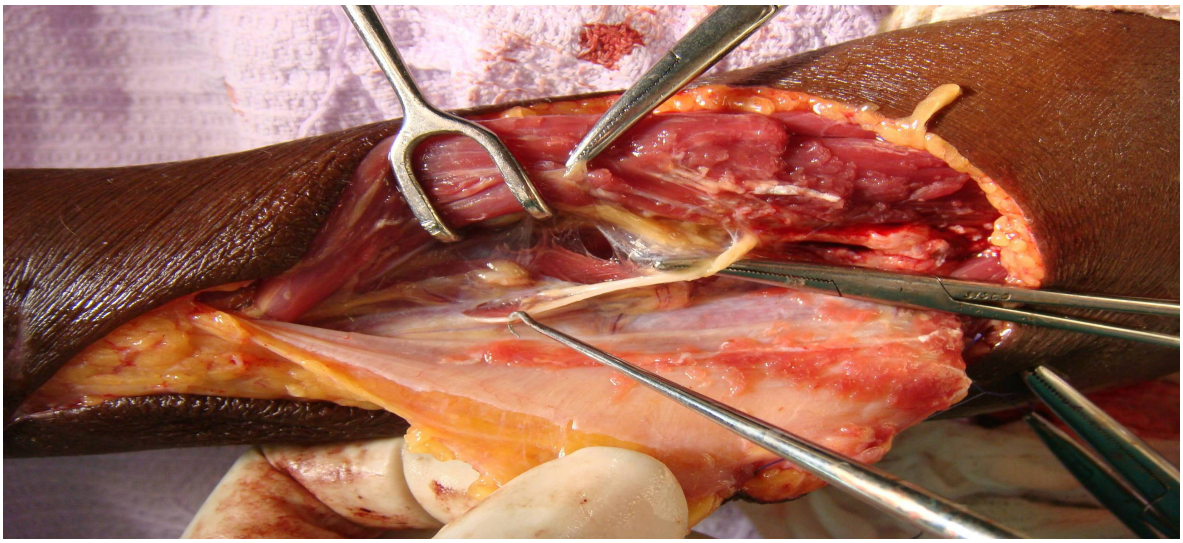
the reverse flow phenomenon. However, the controversy regarding the necessity of test dissection still continues.

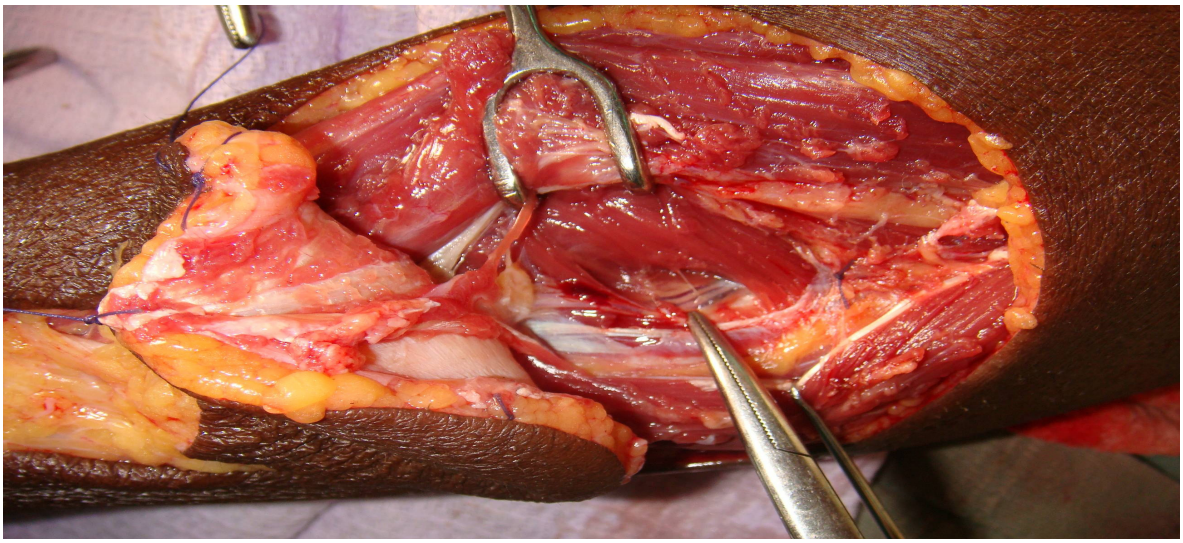
PRE-OPERATIVE PHOTOGRAPH OF CASE 4

PICTURE SHOWING VASCULAR AXIS AND CONFIGURATION OF FLAP

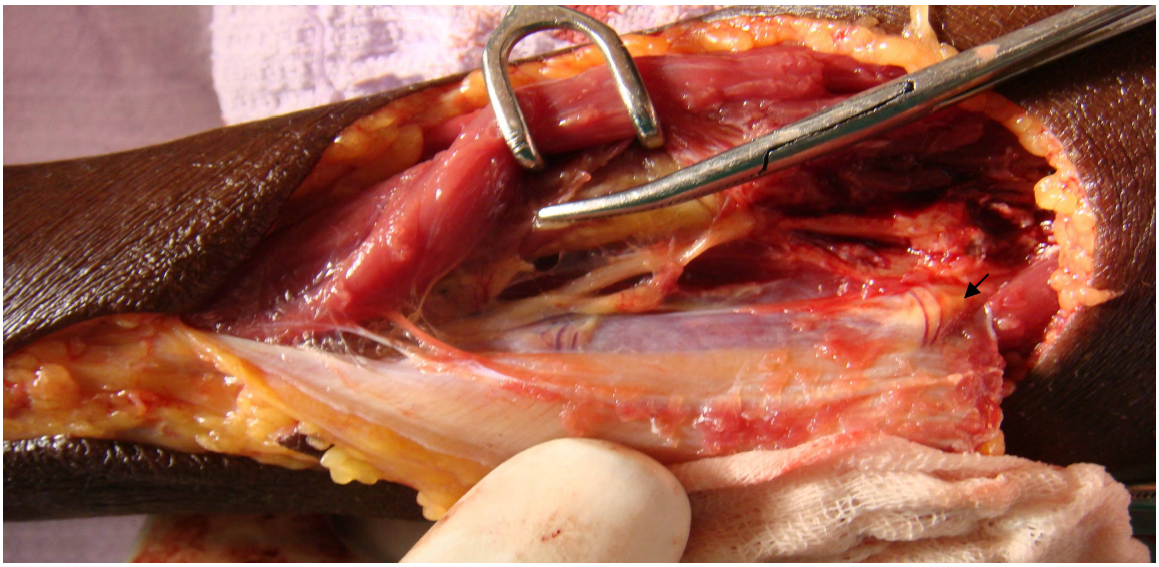
PICTURE SHOWING RELATION OF BRANCH OF PIN TO ECU AND MOST PREDOMINANT CUTANEOUS PERFORATOR OF PIA



PICTURE SHOWING ORIGIN OF PIA WITH ITS VENAE COMITANS AND ITS RELATIONS TO THE SURROUNDING STRUCTURES



PICTURE SHOWING PERFORATOR FROM INTEROSSEOUS RECURRENT ARTERY INCLUDED IN THE FLAP



POST-OPERATIVE PHOTOGRAPH OF CASE 4

ADVANTAGES OF POSTERIOR INTEROSSEOUS ARTERY FLAP

The septo- cutaneous island flap based on the posterior interosseous Artery raised on the posterior aspect of forearm originally described by Zancolli and Angrigiani in 1985 has widespread application in reconstruction of soft tissue defects of the dorsum of hand, wrist and first web space. The major advantage of this flap is that it ***does not require sacrifice of any vessel essential for perfusion of the hand.*** Both the radial artery forearm flap and ulnar artery forearm flap although popular are fraught with disadvantages. Both flaps are based on the integrity of the palmar arches and a major artery for the vascular supply of the hand is sacrificed by flap harvesting. Suominen et al [25] studied 18 patients after elevation of a radial forearm flap using infrared thermography, colour Doppler ultrasound and a

cold provocation test (15 degrees Celsius bath for five minutes). They found that the blood velocity(cm/s) in the ulnar artery of the donor forearm was increased in 13 patients, when compared to the control forearm, and the ulnar/brachial artery flow ratio increased in 11; also, 7 out of 18 patients complained of cold intolerance (39%).

Wheras Braun[26] concluded from his study that the hand was supplied by the ulnar artery and the deep palmar arch, Kleinert et al[27] documented evidence that the ulnar artery is less important than the radial, especially to the all-important radial digits. However it can be emphatically stated that both ulnar and radial arteries are more important than the posterior interosseous artery for the blood supply to the hand. As a consequence ***large fasciocutaneous flaps can be harvested even when the radial or ulnar pedicles are damaged without endangering the***

supply to the hand. The posterior interosseous artery flap is versatile flap in terms of the size of the flap which can vary from 4 by 5 to 14 by 9cm. As a result even cases where there is extensive skin loss due to any reason a single staged reliable regional flap can be give without significant donor site morbidity in terms of function. Compared to staged pedicle flaps and free flaps use of PIA flaps ensures ***shorter hospital stay and cost-effectiveness*** and with the use of medium thickness grafts for donor area, the donor scar has not been an issue in our series. In fact the donor site morbidity of the radial artery forearm flap is much higher. Often patients with hand injuries have abrasions or lacerations over the business area of the PIA flap (dorsum of proximal and mid third of forearm) which may deter hand surgeons from using this otherwise reliable flap. But if pre-operative Doppler study confirms the presence of perforators and reverse flow ***flaps can be raised***

from the zone of injury too. Another advantage is the size of the vessel at its origin which is almost always 2mm or so. This facilitates ***converting the pedicled flap into micro vascular flap in case of doubtful reverse flow during the procedure***. This flap can be used in limited cases of thumb reconstruction where an osteo-cutaneous flap is raised. Another regional flap which does not interrupt the vascular axis is the dorso-ulnar artery flap, its main disadvantage being a short pedicle and limited arc of rotation. The Posterior Interosseous artery flap in contrast has ***a longer pedicle and wide arc of rotation.*** In addition the PIA flap provides soft ***supple skin with good colour and texture match.***

The main disadvantage is in large flaps where the donor area has to In large flaps the donor area has to be covered with a skin graft which according to some authors in unsightly and unacceptable

OBSERVATIONS AND RESULTS

OBSERVATIONS AND RESULTS

1. The axis of the flap was planned on a line joining the lateral epicondyle and ulnar styloid process.

2. In the clinical study there were **13 male** and **7 female** patients.

3. The soft tissue defect in these patients were as a result of

a) Post chemotherapy infusion necrosis: four in number (both Adriamycin based regimens)
b) Post traumatic sequelae: ten in number
c) Post burns sequelae: three in number (electric burn injury)
d) Post Infective sequelae: two in number
e) Post surgical defect: one in number

4. The average age of these patients was **32.4** years.

5. **OBSERVATIONS DURING CLINICAL CASE DISSECTION**:

a) Average site of entry of PIA in the posterior compartment (no. of cm from ulna): **15.3 cm**

b) Percentage of site of origin of Interosseous Recurrent Artery at the level of oblique cord/interosseous membrane: **60%**

Percentage of site of origin of Interosseous Recurrent Artery at the level of Abductor Pollicis longus/ Supinator: **40%**

c) Percentage of dissections in which IRA is present deep to Anconeus: **75%**

Percentage of dissections in which IRA is deep to Anconeus & Supinator: **25%**

d) Percentage of dissections with one perforator from the IRA: **35%**

Percentage of dissections with two perforators from the IRA: **60%**

Percentage of dissections with three perforators from the IRA: **05%**

e) Average size of the PIA in the posterior compartment: **1.94 mm**

f) Percentage of dissections showing modified Buchler and Frey's Phenomena: **30%**

g) Percentage of dissections in which septocutaneous perforators lie between EDC and EDM: **10%**

Percentage of dissections in which septocutaneous perforators lie between ECU and EDM: **90%**

h) Average number of perforators from the PIA: **3.6**

i) Average distance of the first perforator from the ulnar styloid process: **9.5 cm**

j) Average size of PIA at termination : **0.9mm**

k) Average site of anastomosis between PIA and AIA from ulnar styloid process: **3.0 cm**

l) Pedicle management in the clinical cases:

Tunneling: **7**

Exteriorizing the pedicle and grafting: **8**

Skin bridge opened to transfer the flap from pivot point to defect: **5**

m) Largest flap dimensions : **13 by 8 cm**

n) Smallest flap dimensions : **5 by 3.5 cm**

o) **Complications:**

Total flap necrosis: NIL

Rim necrosis: ONE (did not need secondary procedure)

Donor site graft loss: ONE

Graft loss over pedicle: ONE

Venous congestion: NIL

Extensor paresis: NIL

Necessity of secondary surgery: ONE (grafting of donor and pedicle area)

p) All patients had full range of motion following maximum of three weeks after surgery.

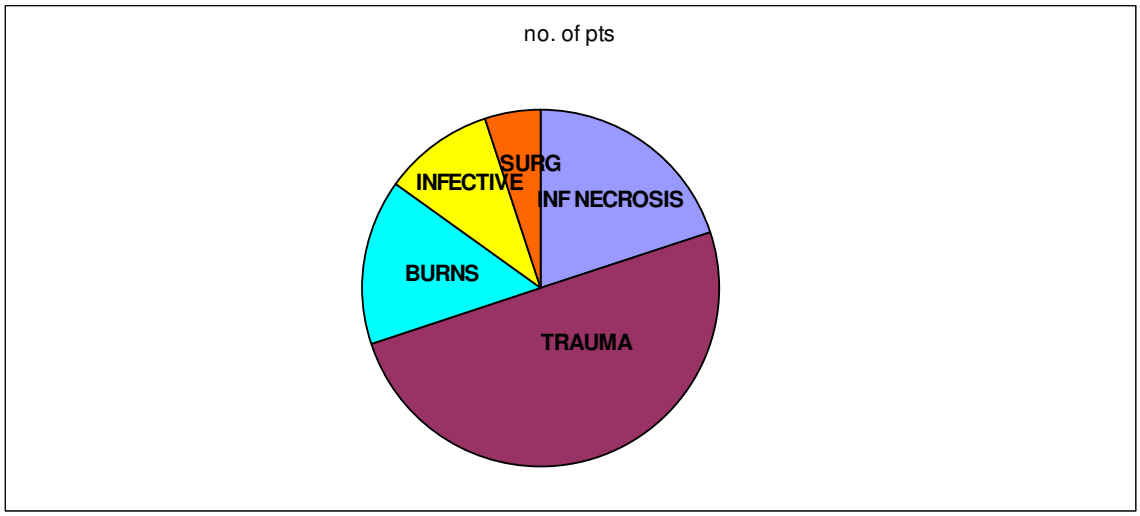


Fig 1 VARIOUS CAUSES OF DEFECTS OVER HAND AND DISTAL FOREARM IN OUR SERIES

Fig 2 TECHNIQUE OF MANAGEMENT OF PEDICLE IN CLINICAL STUDY

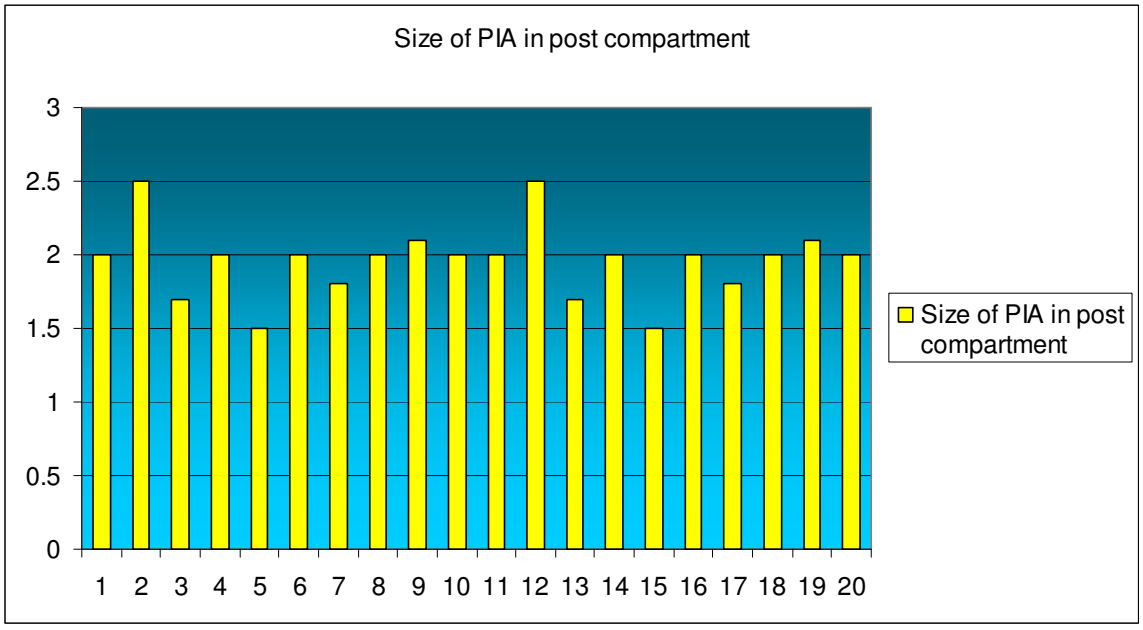


Fig 3 SIZE OF THE POSTERIOR INTEROSSEOUS ARTERY IN THE DORSAL COMPARTMENT OF THE FOREARM IN CLINICAL STUDY IN mm

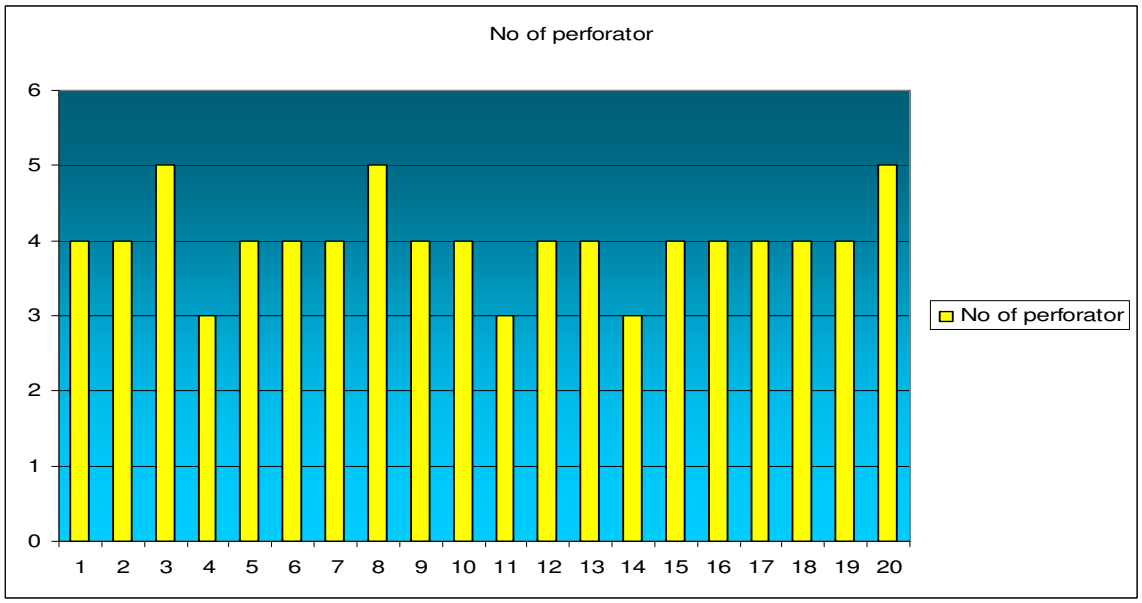


Fig 4 NUMBER OF CUTANEOUS PERFORATORS FROM THE POSTERIOR INTEROSSEOUS ARTERY IN CLINICAL STUDY

PRE-OPERATIVE PHOTOGRAPH OF CASE 1

POST OPERATIVE PHOTOGRAPH OF CASE 1

PRE-OPERATIVE PHOTOGRAPH OF CASE 2

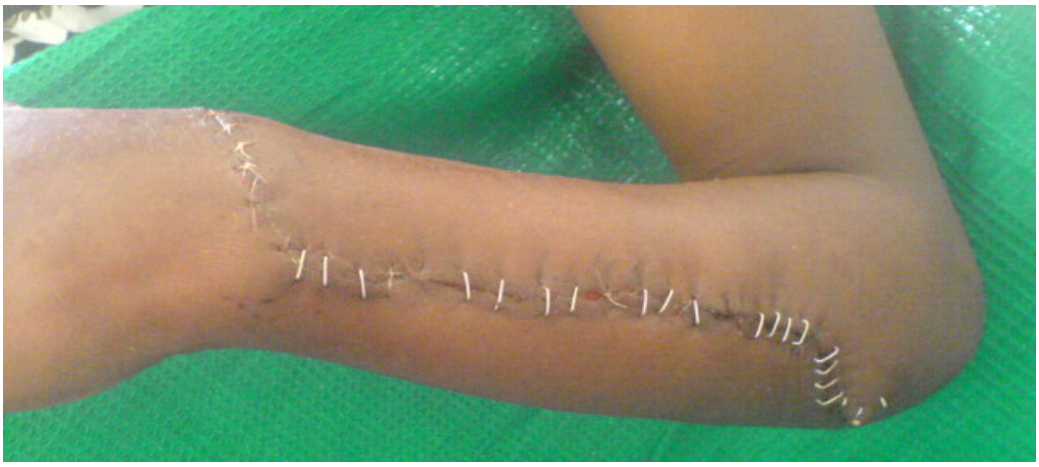
POST OPERATIVE PHOTOGRAPH OF CASE 2

PRE-OPERATIVE PHOTOGRAPH OF CASE 3

POST- OPERATIVE PHOTOGRAPH OF CASE 3

PICTURE SHOWING FLAP USED FOR ADDUCTION CONTRACTURE RELEASE IST WEB SPACE CASE 8

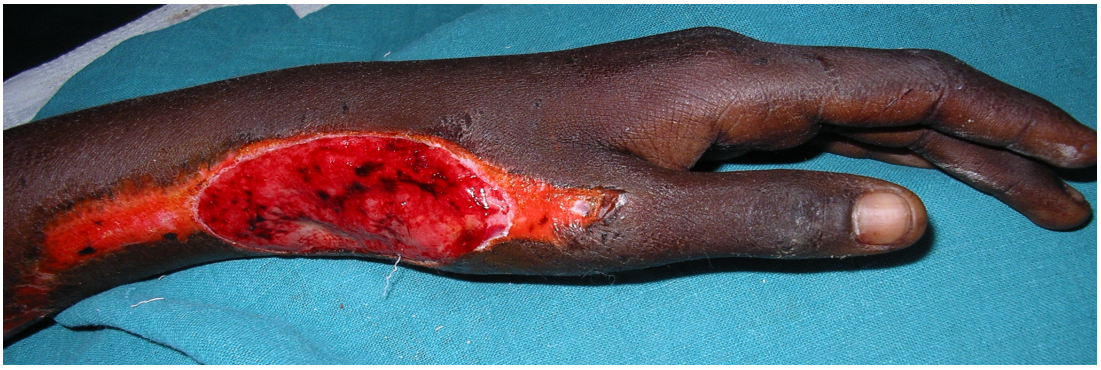
PICTURE SHOWING PRIMARY CLOSURE OF DONOR SITE CASE 8



PICTURE SHOWING DONOR SITE AND FLAP INSET IN CASE 7

POST-OPERATIVE CASE 5 IN WHICH REPAIR OF FLEXOR TENDONS, MEDIAN NERVE AND PIA FLAP COVER WAS DONE

PRE-OPERATIVE PHOTOGRAPH OF CASE 10



INTRA-OPERATIVE PHOTOGRAPH SHOWING FLAP DIMENSIONS AND ADIPOFASCIAL PEDICLE CASE 10

OBSERVATIONS DURING CADAVERIC DISSECTION

a) Average site of entry of PIA in the posterior compartment (no. of cm from ulnar styloid): **14.6 cm**

b) Percentage of site of origin of Interosseous Recurrent Artery at the level of oblique cord/interosseous membrane: **60%**

Percentage of site of origin of Interosseous Recurrent Artery at the level of Abductor Pollicis longus/ Supinator: **40%**

c) Percentage of dissections in which IRA is present deep to Anconeus: **70%**

Percentage of dissections in which IRA is deep to Anconeus & Supinator: **30%**

d) Percentage of dissections with one perforator from the IRA: **30%**

Percentage of dissections with two perforators from the IRA: **60%**

Percentage of dissections with three perforators from the IRA: **10%**

e) Average size of the PIA in the posterior compartment: **1.84 mm**

f) Percentage of dissections showing modified Buchler and Frey's Phenomena: **30%**

g) Percentage of dissections in which septocutaneous perforators lie between EDC and EDM: **10%**

   Percentage of dissections in which septocutaneous perforators lie between ECU and EDM: **90%**

h) Average number of perforators from the PIA: **3.0**

i) Average distance of the first perforator from the ulnar styloid process: **10 cm**

j) Average size of PIA at termination : **0.9mm**

k) Average site of anastomosis between PIA and AIA from ulnar styloid process: **2.8 cm**

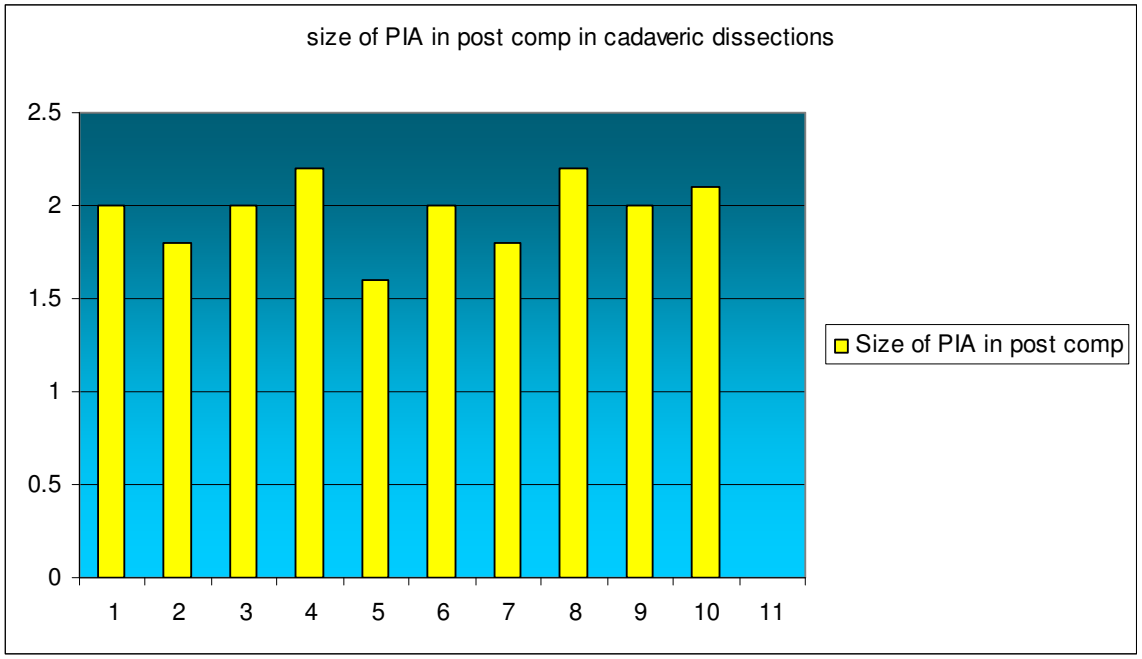


Fig 5 SIZE OF POSTERIOR INTEROSSEOUS ARTERY IN CADAVERIC DISSECTIONS IN mm

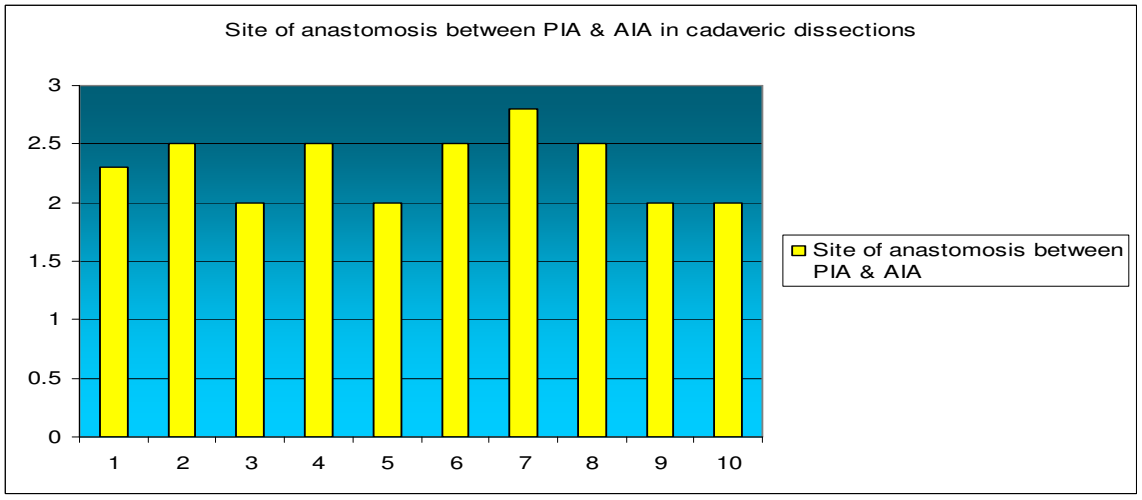


Fig 6 SITE OF ANASTOMOSIS BETWEEN ANTERIOR AND POSTERIOR INTEROSSEOUS ARTERY IN CMS FROM ULNAR STYLOID (CADAVERIC)

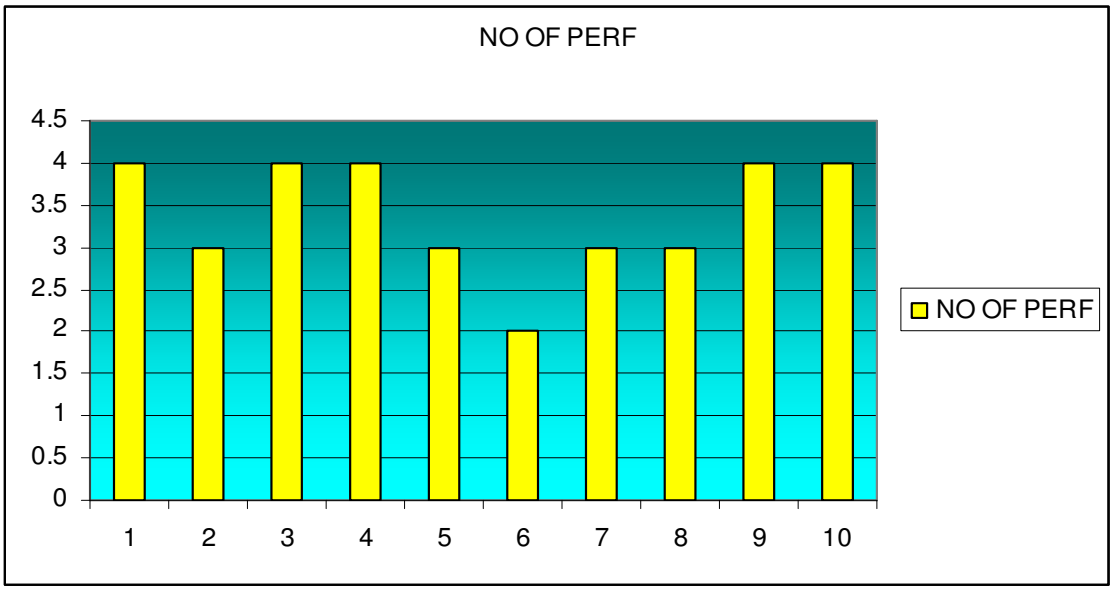
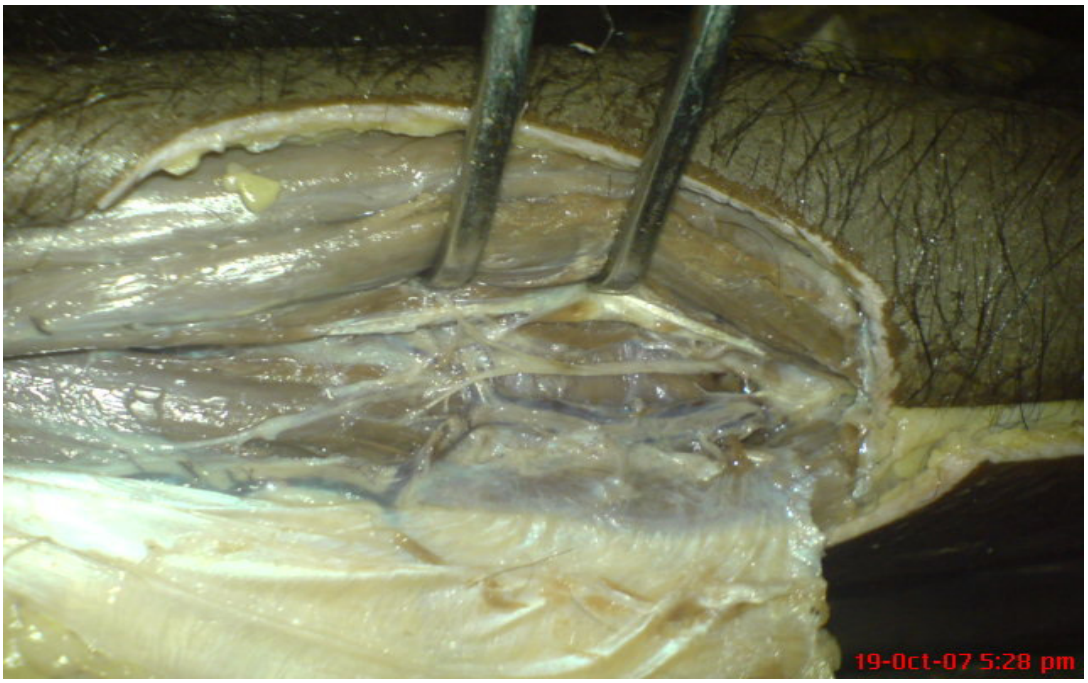


Fig 7 NUMBER OF PERFORATORS FROM THE POSTERIOR INTEROSSEOUS ARTERY IN CADAVERIC DISSECTIONS

PICTURE SHOWING THE PIA AND ITS CUTANEOUS AND MUSCULOCUTANEOUS PERFORATORS (CADAVERIC DISSECTION)



PICTURE SHOWING RELATION OF POSTERIOR INTEROSSSEOUS NERVE WITH ARTERY (CADAVERIC DISSECTION)

DISCUSSION

DISCUSSION

This study has helped to evolve a methodology of dissection for safe raising of the Posterior Interosseous Artery flap and recruiting larger tissue from the proximal third of forearm. ***None of our cases were preceded by a test dissection*** and a patent anastomosis between the Anterior and Posterior Interosseous artery and good reverse flow was found in all our cases. In all our cadaveric and clinical dissections the vascular axis of the pedicle distally deflected towards the ulnar styloid process. Anatomically also the index septum between the Extensor Carpi Ulnaris and the Extensor Digiti Minimi deflects towards the ulnar styloid because the Extensor Carpi Ulnaris runs on the groove on the dorsal aspect of the distal end of the ulna, leaving the distal

end of the Posterior Interosseous Artery arching in the septo-periosteal condensation, before making anastomosis with the Anterior Interosseous Artery. So, the study points towards the ***validity of our surface marking of the axis of the flap (from lateral epicondyle to ulnar styloid).***

After outlining the flap dimensions the flap is raised with dissection starting from the ulnar side raising a fasciocutaneous unit. The dissection is continued till ***the septum between the Extensor Digiti Minimi and Extensor Carpi Ulnaris*** is reached. From now the flap is dissected from its radial aspect until the septum is reached. During the dissection from the radial side, in all our dissections upon retracting the extensor digitorum communis the ***extensor digiti minimi is found to be a thin muscle enclosed in a separate fascial compartment.*** After making an incision longitudinally over the

muscle, disto-proximally the myofibres of the EDM which are attached to the index septum is carefully dissected away ligating one or two muscle perforators from the PIA. Throughout the dissection the ***attachment of the fascia over Abductor Pollicis Longus and Supinator is maintained.*** Proximally the dissection is carried out under the Anconeus over the Supinator. In all our dissections ***the PIA within the fibres of the Supinator divides into PIA proper and the Interosseous Recurrent Artery***. The Interosseous Recurrent Artery runs through few distal fibres of the Supinator and in 50% of cases it runs through the connective tissue between the Supinator and APL. The ***Interosseous Recurrent Artery runs at the base of of the index septum under the Anconeus over the Supinator giving rise to 2 or 3 direct cutaneous perforators to the overlying skin.*** In raising a larger flap we have

done proximal dissection and protected the index septum prolongation which carries the perforators from the IRA . Except for one case where there was 0.5cm distal necrosis, all flaps survived in the entirety. We have successfully included 8cm by 8cm of cutaneous territory of the IRA as an extension of the conventional PIA territory with no complications. During raising of flap the dissection is carried out on the surface of Supinator after dividing and ligating the IRA proximally. In 50% of our cases the superficial fibres of distal supinator are divided carefully to reach the Y-stem of PIA after it has pierced the interosseous membrane. Following the ***Y-V principle of Baudet*** we have ligated the stem of PIA close to the interosseous membrane.

The dissection is continued from both radial and ulnar aspect distally where the AP dimensions of the septum are reduced and the

vessels are superficially running over the Extensor Indices Proprius. We ***proceed distally by carefully dissecting the sub-epimyseal plane of APL, EPL and EIP.*** During the dissection at an average distance of 16cm from the ulnar styloid process ***the nutrient artery to the ulna is identified***. There were multiple perforators to APL, one to EIP and two to EPL in all our dissections which were ligated during raising of the flap. ***Distally the PIA runs very close to the periosteum of ulna, radial to the ECU which is situated in the groove on the dorsal surface of ulnar styloid***. From there on the ulnar directed smooth arch like bending of the artery runs beneath Extensor Digiti Minimi and Extensor Digiti Communis to make anastomosis with the Anterior Interosseous Artery. In one of our dissections the ***pulsatile reverse flow was seen upto the proximal end of the flap*** after the flap was

completely raised from the bed which reinforces the Angiosomal dynamic recruitment based on the Y-V principle of Baudet.

In 30% of our dissections the ***Posterior Interosseous Nerve runs radially between the superficial and deep fibres of the Supinator and gives a branch which perforates through the proximal end of the septum.*** After emerging between the superficial and deep fibres of the supinator the posterior interosseous nerve runs on the radial aspect of the posterior interosseous artery and its venae comitans. In relation to the proximal most perforator from the PIA we have observed in our studies that the branch to the Extensor Carpi Ulnaris is given off well proximally as it runs on the substance of the Supinator. In 65% of our cases as the flap was raised the proximal most border of the index septum is wedged out in the

acute angle between the Posterior Interosseous nerve and its branch to the ECU and teased out without the need for division of the branch. Hence chances of denervation of the strong wrist extensor is decreased. In 35% of our cases as the branch to the ECU passes distal to the most proximal perforator of the PIA it is divided and subsequently anastomosed (***Modified Buchler and Frey phenomenon***)[28] without any significant post-operative paresis.

INTERPRETATION ON THE BASIS OF THE ANGIOSOMAL CONCEPT

BONE: The nutrient artery to the ulna was given off at 15-17cm from the tip of ulnar styloid process from the PIA passing through the Abductor Pollicis Longus and sometimes Extensor Pollicis Longus and then entering the bone 10-12 cm from the ulnar styloid process.

This endosteal blood supply from the PIA is re-inforced by the arcuate blood supply from attachment of Abductor Pollicis Longus, Extensor Pollicis Longus and Extensor Indicis Proprius.

MUSCLE: The PIA gives musculocutaneous perforators which ramify on the fascial skeleton between the Extensor Digitorum Communis, Extensor Digiti Minimi, Extensor Carpi Ulnaris on the superficial aspect and Abductor Pollicis Longus, Extensor Pollicis Longus and Extensor Indicis Proprius and supinator on the deeper aspect. All the superficial and deep muscles of the extensor compartment except the Brachioradialis, Extensor Carpi Radialis Longus and Extensor Carpi Radialis Brevis are supplied by the PIA, the remaining three being supplied by the brachial artery, radial artery and the radial recurrent artery.

NEURAL SUPPLY: The Posterior Interosseous Nerve receives one or two slender branches as soon as it emerges from the supinator muscle. The distal half of the nerve receives its blood supply from the wrist anastomosis.

CUTANEOUS TERRITORY: The skin over the middle third of the dorsum of forearm as per the observation made by Zancolli is supplied by 2-3 perforators from the PIA. The skin over proximal third of the forearm overlying the Anconeus also receives 2-3 perforators as per our observation either directly or musculocutaneous through the Anconeus from the IRA. In the distal third of the forearm there are direct cutaneous perforators passing between the Extensor Carpi Ulnaris and Extensor Digiti Minimi which are three in number situated at an average distance of 6cm, 7cm and 9cm from the ulnar styloid

process as per our observations. In addition to the direct cutaneous perforators passing between Extensor Digiti Minimi and Extensor Digitorum Communis for the middle third there are 2 paired venae comitans consistently found in all our 30 dissections running on either side of PIA more definable towards the hilum between the Supinator and the APL. The average caliber of the PIA at the hilum was 2.0mm and at the distal end was 0.9mm.

In eight of our clinical cases and four cadaveric dissections there is a dorsal forearm vein running all along the dissection in the subcutaneous plane upto proximal end of the flaps. We have preserved this vein during our dissection distally over the pedicle by subdermal dissection.

CONCLUSIONS

CONCLUSIONS

1) The fundamental basis of the Posterior Interosseous artery flap adheres to the ANGIOSOMAL concept

2) Test dissection is not required. Pre operative Doppler sufficient to establish anastomosis between AIA and PIA and the reverse flow. The anastomosis between the Anterior Interosseous and Posterior Interosseous Artery is consistently present in all our dissections and reverse flow was seen by pulsation of the artery after division.

3) The flap can be safely raised and larger tissue can be recruited by proximally including the Anconeus muscle, proximal perforators from the Interosseous Recurrent Artery and by 'Y' ligation of the artery beneath the origin and subsequently by sub-epimyseal dissection upto the distal end

of the PIA where it anastomoses with the AIA. Raising the flap in a tear-drop configuration helps to relieve tension over the pedicle.

4) The axis of the flap is planned along a line joining the lateral epicondyle and the ulnar styloid process and not the distal radio-ulnar joint as described by previous authors.

5) The flap has good color, texture and thickness match with potential for neurotisation. There is sparing of the axial vessels, and morbidity of donor area is negligible. The weakness of ulnar extension due to ECU paresis was found to be negligible.

6) The Buchler and Frey phenomena was noted and in 35% of our cases the branch of PIN was divided and re-anastomosed.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. R. Page and J.Chang**. Reconstruction of Hand Soft-Tissue Defects: Alternatives to the Radial Forearm Fasciocutaneous Flap** *The Journal of Hand Surgery, May 2006*; 31(5): *847-856*

2. I.O. Golubev and E.A. Pavlenko. **Surgical potentialities of posterior interosseous flap in hand and fingers reconstruction.** *Journal of Hand Surgery: European Volume, June 2007*; 32(1): *123*

3. **Posterior interosseous artery flap in traumatic hand injuries** *Archives of Orthopaedic and Trauma Surgery,* 2003; 132(7): *323-326*

4. R.E. Giunta. **Local Flaps in Hand Surgery** *European Surgery-Acta Chirurgica Austriaca, June 2003; 35(3): 148-156*

5. P. Bayon and R.W.H. Pho. **Anatomical basis of forearm flap based on posterior interosseous vessels** *Journal Of Hand Surgery, 1988; 13: 435*

6. E.A. Zancolli and C. Angrigiani**. Posterior interosseous island forearm flap** *The Journal of Hand Surgery: Journal of the British Society for Surgery of the Hand, May 1988*; *13(2): 130-135*

7. H. Costa, A. Pinto and H. Zenha. **The posterior interosseous flap – a prime technique in hand reconstruction. The experience of 100 anatomical dissections and 102 clinical cases** *Journal of Plastic, Reconstructive & Aesthetic Surgery, July 2007*; 60(7): *740-747*
8. H. Costa and D.S. Soutar. **The distally based island posterior interosseous flap** *British Journal of Plastic Surgery, May 1988; 41(3): 221-227*

9. N. Mazzer, C.H. Barbieri and M. Cortez. **The posterior interosseous forearm island flap for skin defects in the hand and elbow: A prospective study of 51 cases** *The Journal of Hand Surgery: Journal of the British Society for Surgery of the Hand, April 1996; 21(2): 237-243*

10. H. Costa, C. Cunha, A. Conde, M.L. Gracia, J. Vranchx and D. Soutar. **The posterior interosseous flap: a review of 81 clinical cases and 100 anatomical dissections — assessment of its indications in reconstruction of hand defects** *British Journal of Plastic Surgery, January 2001; 54(1): 28-33*

11. C.V. Penteado, A.C. Masquelet, J.P. Cheveral, et al **Anatomical Basis of the asciocutaneous flap of the posterior interossous artery** *Surg Radiol Anat,, 1986; 8: 209*

12. F. Dap, G. Dautel, P. Voche, et al. **The Posterior interosseous artery flap in primary repair of hand injuries.** *Journal of Hand Surgery 1993; 18(4): 437-445*

13. U. Buchler, H.P. Frey. **Retrograde Posterior Interosseous Artery Flap** *Journal Of Hand Surgery, 1991; 16A: 283-292*

14. Y.C. Ding, G.C. Sun, Y. Lu, et al **The Vascular Microanatomy of skin territory of posterior forearm and its clincal applications** *Annals Of Plastic Surgery, 1989; 22: 126-134*

15. B.J. Anson and Morris. **Human Anatomy In: The Nervous System.** Francs, C.C; I.J. Edr. 12th

Edu Mc Graw Hill Book Co. New York: p 1069. (1953)

16. F. Brunelli, P. Valenti, C. Dumontier, et al **The Posterior Interosseous reverse flap: Experience with 113 flaps.** *Annals of Plastic Surgery 2001; 47: 25-30*

17. H.C. Chen, M.H. Cheng, A.G. Schneeberger, et al **Posterior Interosseous flap and its variations for coverage of hand wounds.** *J Trauma 1998; 45: 570-574*

18. H. Koch, A. Kursumovic, M. Hubmer et al. **Defects on the dorsum of hand- the posterior interosseous flap and its alternatives.** *Hand Surg 2003; 8: 205-212*

19. C. Angrigiani, D. Grilli, D. Dominikow. **Posterior Interosseous reverse forearm flap: experience with 80 consecutive cases.** *Plast Reconstr Surg 1993;92:285-293*

20. E. Riccardo, Giunta and B. Lukas. **Impossible harvest of the posterior interosseous artery flap: a report of an individualised salvage procedure** *British Journal of Plastic Surgery*, *December 1998*; *51(8): 642-645*

21. A. Gupta, W. Wang, Baylis and W. Breidenbach. **Anterior transposition of the posterior interosseous artery flap through the interosseous membrane** *The Journal of Hand Surgery: Journal of the British Society for Surgery of the Hand*, *February 1997*; *21: 32-33*

22. L.G. Dadalt, H.J.R. Ulson and C.V. Penteado. **Absence of the anastomosis between the anterior and posterior interosseous arteries in a posterior**

interosseous flap: A case report *The Journal of Hand Surgery, January 1994; 19(1): 22-25*

23. M.A. Tonkin and H. Stern. **The posterior interosseous artery free flap** *The Journal of Hand Surgery: Journal of the British Society for Surgery of the Hand, May 1989; 14(2): 215-217*

24. G.I. Taylor. **The Doppler probe for planning flaps: anatomical study and its clinical applications**. *Br J Plast Surg 1990; 43: 1-16*

25. S. Suominen, S. Asko-Seljavaara and J. Attovuo. **Thermography and color Doppler ultrasonography of hands after radial forearm flap elevation.** Presented at the 5th annual meeting of the European association of Plastic surgeons May 14 1994, Geneva, p 95

26. J.B. Braun. **Les arteres' These, University de Nancy**

27. J.M. Kleinert, S.G. Fleming, R.M.C. Abel, et al. **Radial and Ulnar artery dominance in normal digit.** *J Hand Surg* 1989; 14A: 504-508

28. U. Buechler, H.P. Frey, **Retrograde posterior interosseous flap.** *J Hand Surg* 1991; 16A: 283-92

PROFORMA FOR THESIS

TITLE: To study the anatomical variations in Posterior Interosseous artery and its clinical applications

S.No

MATERIAL: Clinical / Cadaveric

If Clinical:
Name: Age: Sex:

Primary Condition Co-morbid condition

METHODS:

Proximal third of forearm

Entry of PIA in the posterior compartment:
Site of origin of Interosseous recurrent artery: (oblique cord/ interosseous membrane):
Course of IRA (Deep to Anconeus/ Anconeus & Supinator)
No. of perforators from IRA:
Size of PIA in the post comptt:
Relation of PIN and PIA (Buechler and Frey phenomenon):

Middle third of forearm

Course of PIA:
Location of septo-cutaneous perforators (EDC-EDM/EDM-ECU)
No. of perforators:
Size of perf at origin:

Distal third of forearm

Course of vessel (no. of cm from ulna)
Site of anastomosis between AIA and PIA

MASTER CHART FOR CLINICAL CASES

					Proximal 1/3					Middle 1/3			Distal 1/3		
			Entry Of PIA In post comp	Site of origin of IRA from PIA*	Course of IRA #	No of perf from IRA	Size of PIA in post compartment	Relation of PIA to PIN	No of cm from ulna styloid process	Location of septocut perf!	No of perforator	Size of perforator at origin	Course of vessel, cm from US	Site of anastomosis between PIA & AIA	
1	Sampathi Bai 70/F	Post CT infusion necrosis Rt hand	15.0	1	2	2	2	B+	13	2	4	0.8	3	2.5	6 by 5
2	Savithri 42/F	Post CT infusion necrosis Lt hand	17.5	2	1	1	2.5	B-	15	1	4	0.9	3.5	3	13 by 8
3	Shanthi 32/F	Post elec burns. defect Rt thumb	14	2	1	1	1.7	B+	13	2	5 all thro' EDM to skin	1.2	3	2.5	7 by 4
4	Usha 48/F	Comp # BB Lt FA – defect on volar aspect	16	2	1	1	2	B-	14	2	3	1	3	2.5	7.2 by 6.5
5	Rejendran 24/M	Soft tissue defect ulnar aspect Rt FA	16	1	1	2	1.5	B+	13.5	2	4	1	3.5	3	7 by 6
6	Govindraj 36/M	Rt thumb defect volar aspect	16.5	1	2	2	2	B-	14	2	4	1.2	3	2.5	5 by 3
7	Ganhadaran 38/M	PI 3rd web space defect	16	2	1	1	1.8	B-	14	2	4	0.9	3	2	6 by 4
8	Alexander 20/M	Adduction contracture 1st web space	17	2	2	2	2	B-	13	2	5	0.8	3.5	2	7 by 4
9	Arun Kumar 14/M	Post electric burns sequelae	16.5	2	1	2	2.1	B-	13	2	4	1.0	3.5	2.5	8 by 5
10	Viknesh 15/M	Post traumatic sequelae	16	2	1	2	2.0	B-	13.5	2	4	1.0	3	2	6 by 3

*Site of origin of IRA 1- Oblique cord 2- Interosseous membrane

Course of IRA 1-Deep to Anconeus 2- Deep to Anconeus/ Supinator

! Location of septocutaneous perforators 1- EDM-EDC 2-EDM-ECU

MASTER CHART FOR CLINICAL CASES

			Entry Of PIA In post comp	Site of origin of IRA from PIA*	Course of IRA #	No of perf from IRA	Size of PIA in post compartment	Relation of PIA to PIN	No of cm from ulna styloid process	Location of septocut perf !	No of perforator	Size of perforator at origin	Course of vessel, cm from US	Site of anastomosis between PIA & AIA	
11	Pattani 48/M	Post CT infusion necrosis Rt hand	15.0	1	2	2	2.0	B+	14	2	3	0.8	3	2.5	7 by 5
12	Sai Priya 13/F	Vascular malformation R hand dorsum	16	2	1	1	2.5	B-	13.5	1	4	0.9	3.5	3	5 by 3.5
13	Devi 56/F	Post CT infusion necrosis Lt hand	17	2	1	1	1.7	B+	13	2	4	1.2	3	2.5	7 by 4
14	Vijay 16/m	Comp # 3rd, 4th metacarpal, ext injury R hand	16	2	1	3	2.0	B-	13	2	3	1	3	2.5	6 by 4
15	Jeyalakshmi 37/F	PT soft tissue defect dorsum of left hand	16	1	1	2	1.5	B+	15	2	4	1	3.5	3	11 by 5
16	Solomon 25/M	Post VIC adduction contracture left 1st web space	16.5	1	2	2	2.0	B-	13	2	4	1.2	3	2.5	5 by 3
17	Manivel 18/M	Post burn contr left wrist after release	17.5	2	1	1	1.8	B-	14	2	4	0.9	3	2	10 by 5
18	Gopal 40/M	Post traumatic defect Lt hand dorsum	14	2	2	2	2.0	B-	14	2	4	0.8	3.5	2	9 by 4
19	Suresh 38/M	Post infective sequelae R thumb	16.5	2	1	2	2.1	B-	13	2	4	1.0	3.5	2.5	8 by 5
20	Srinivasan 22/M	PT defect distal third R forearm	16	2	2	2	2.0	B-	13	2	5	1.0	3.0	2.5	5 by 4

*Site of origin of IRA 1- Oblique cord 2- Interosseous membrane # Course of IRA 1-Deep to Anconeus 2- Deep to Anconeus/ Supinator! Location of septocutaneous perforators 1- EDM-EDC 2-EDM-ECU

S.No.	CADAVERIC DISSECTION												
	PROXIMAL 1/3						MIDDLE 1/3				DISTAL 1/3		
	Entry of PIA in post comp	Site of origin of IRA from PIA*	Course of IRA#	No: of perforators from IRA	Size of PIA in post comp	Relation of PIA & PIN	PIA No of CM from US	Location of septo cutan flap!	No of perf	Size of perf artery origin	Course of vsl cmfrom US	Site of anastomosis between PIA & AIA	
1	16	1	2	1	2.0	F+	13.5	2	4	0.8	3.0	2.3	
2	17	1	1	1	1.8	F-	14	2	3	0.7	3.0	2.5	
3	16	1	1	2	2.0	F+	14	2	4	0.8	2.5	2.0	
4	15.5	2	1	2	2.2	F-	13	1	4	1.0	3.5	2.5	
5	15	1	2	2	1.6	F-	14	2	3	0.8	3.0	2.0	
6	15	2	1	1	2.0	F-	14.5	All muscle	2	0.8	3.0	2.5	
7	16.5	2	1	1	1.8	F+	13	2	3	0.9	3.5	2.8	
8	16	1	1	2	2.2	F-	13	2	3	1.0	3.0	2.5	
9	17	1	2	2	2.0	F-	13.5	2	4	1.0	3.2	2.0	
10	16.5	1	1	3	2.1	F-	13.5	2	4	0.9	3.0	2.0	

INFORMED CONSENT FOR THE STUDY

I (Patient's name) give my full free and voluntary consent to participate in this study and I am fully aware that my photographs may be published. I have been explained the nature of the study and the procedure by the doctor in the language best understood by me.

Patient's signature or thumb impression

Witness signature or thumb impression

Doctor's signature